newer Universities, and that they are still convinced that Great Britain has only two institutions worthy of the title. Have they any adequate conception, for example, of the extent and capacities for teaching and research of the faculties and departments of metallurgy, engineering, chemistry, and applied electricity at Sheffield, Leeds, Manchester, and Liverpool, to mention only one group of provincial Universities, and how it might be possible, in connection with a properly organised training corps, to provide instruction for cadets in those branches of specialised military work for which a particular University had special facilities and equipment, involving the application of science to war?

The Regulations governing the O.T.C. are dated 1912, but we have learnt much since then, and it is essential before these Regulations are revised and re-issued that the Army Council should take the Universities into its confidence, and, in consultation with their representatives, produce a scheme of training that shall conform to University practice and be within the range of University capacity, while at the same time meeting the requirements of the Army Council in its effort to obtain suitably trained men to command the various units of the Army of the future.

Relativity and Geometry.

The Foundations of Einstein's Theory of Gravitation. By Erwin Freundlich. Authorised English translation by Henry L. Brose. Preface by Albert Einstein. Introduction by Prof. H. H. Turner. Pp. xvi+61. (Cambridge: At the University Press, 1920.) Price 5*s.* net.

PURELY mathematical workers have often found occasion to remark on the prophetic vision of Riemann. He possessed that special genius which catches glimpses of truth, of no special significance to a contemporary, which one day are found to have an importance greater even than the seer himself had dreamed. Certainly this has proved so with much of Riemann's work. His famous *Habilitationsschrift*, "On the Hypotheses which lie at the Bases of Geometry," was presented to the faculty of philosophy at Göttingen in 1854, and, in an English translation by Clifford, was brought to the notice of the British public in the columns of NATURE (vol. viii., Nos. 183–84, pp. 14–17, 36, 37). It may be permissible to quote one or two prophetic phrases:

"It seems that the empirical notions on which the metrical determinations of space are founded, the notion of a solid body and of a ray of light, cease to be valid for the infinitely small. We are therefore quite at liberty to suppose that the metric relations of space in the infinitely small do not conform to the hypotheses of geometry; and we ought in fact to suppose it, if we can thereby obtain a simpler explanation of phenomena."

It is worthy of note that Riemann never speaks of space itself as being non-Euclidean. He carefully refers always to the metric or measured relations. The "ground" of these metric relations is to be sought in the nature of the reality underlying space. Is that reality a discrete manifoldness, or is it continuous? If the latter, then the "ground of the metric relations" must be sought in the properties of that reality, or, as he says, "in binding forces which act upon it." Could anything be more prophetic of Einstein's conception of gravitation? Then, as if to anticipate the conservative and the scoffer of to-day, he continues:

"The answer to these questions can only be got by starting from the conception of phenomena which has hitherto been justified by experience, and which Newton assumed as a foundation, and by making in this conception the successive changes required by facts which it cannot explain. Researches starting from general notions, like the investigation we have just made, can only be useful in preventing this work from being hampered by too narrow views, and progress in knowledge of the interdependence of things from being checked by traditional prejudices."

With this open mind, and the work of Gauss, Lobatchevsky, and Bolyai on the geometry of figures on curved surfaces to provoke thought, Riemann faces the possibility that the geometry of three dimensions of actual material bodies may not be so simple as Euclid's system suggests. Geometry in the ordinary sense is, in fact, eliminated; the metrical relations of bodies are "studied in abstract notions of quantity"; the results of calculation may afterwards be expressed in geometric form. Indeed, what is meant by the "length of a line," or a "line element," becomes far from clear from the geometrical point of view. It is merely some quantity which serves to distinguish one point from another. The question is asked: What type of magnitude may be constructed out of the quantities that serve to define two special points in a material body, which may conveniently be taken as a measure of their distinctness one from the other, first from a purely mathematical point of view, but afterwards by an empirical test of its abiding value. Riemann is led to use the general quadratic differential form as the simplest possible expression.

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It is easy for one writing now to see the organic connection between Riemann's thought and the step made by Einstein in passing from the special principle of relativity propounded in 1905 to the general theory now established. The recognition of the relative nature of time measurement had already been made in the special principle, and Minkowski quickly perceived that our separate concepts of space and time were thereby brought into a unity. It seems now but a short step to apply Riemann's analysis to this four-dimensional view of the universe.

But questions still linger; the romance of relativity, its sweeping comprehensiveness, leave us breathless. When Dr. Freundlich tells us that "space is banished out of physical laws altogether: just as æther was eliminated out of the laws of electrodynamics by the special theory of relativity," we must pause and ask ourselves if enthusiasm is not going too far. Dr. Freundlich himself finds the mainspring of Einstein's method in two fundamental postulates: (i) that of continuity; (ii) that of causal relationship between only such things as lie within the realm of observation. It was the craving for *continuity* that gave rise to Faraday's conception of tubes of force, developing gradually into the electromagnetic æther. It is the instinctive faith in the second postulate that leads the timid to distrust the formidable array of differential equations between an army of variables that represent the gravitational field in Einstein's theory.

No physical theory has the power to forbid the mind to use the firm scaffolding of Euclidean truth on which to build its own representation of the universe. True, it may be that the representation is not so simple as we had thought; that the Euclidean element of length does not correspond exactly to a measured interval in a rigid body. But the work of the exponents of relativity is not finished until an added clearness is given by them to the picture of how natural phenomena are related. The æther must not be put on the scrap-heap, but must be rehabilitated. Space must not be spoken of as warped, for that is to leave far behind the essential nature of space as a mode of apprehension. The only true continuum is that which the mind conceives. Matter cannot be a singularity in mental space; it can only be a singularity in the picture drawn upon that background. Matter is one and minds are many. So many minds, so many pictures of matter. The correspondences between the pictures are the grounds of our intellectual intercourse, the only evidence of the external world which we possess.

To turn over the pages of this pamphlet is to encounter many questions; nevertheless the reader will have nothing but thanks to offer to the author, and especially to Mr. Brose, who, while yet a prisoner in an enemy country, found solace in truth that transcends racial strife, and translated it for our enjoyment.

E. CUNNINGHAM.

Colloidal Therapy.

The Use of Colloids in Health and Disease. By Alfred B. Searle. With foreword by Sir Malcolm Morris. (The Chadwick Library.) Pp. vii+120. (London: Constable and Co., Ltd., 1920.) Price 8*s*. net.

BASED on a lecture delivered at the request of the Chadwick Trustees, this volume provides in compact form an account of the principal facts which are known at the present time regarding matter in its colloidal form, with special reference to the utilisation of colloids in the normal animal organism and in the treatment of disease.

We find a lucid account of the physical properties of colloidal matter and of its reactions in the presence of ionising currents, of electrolytes, of radiations, etc. There is explained in simple scientific language the colloidal nature of cellular protoplasm and the selective permeability of cell membranes for salts and colloids.

The importance of the relatively high content of the protective colloid, lactalbumin, in human milk in relation to its digestibility is emphasised, and the means are stated by which cow's milk may be rendered more suitable for human consumption. In discussing the colloidal nature of the blood, reference is made to the adsorption theory of the conveyance of blood gases and to the phenomena of hæmolysis; an isotonic saline solution is, however, 0·9 per cent. sodium chloride.

The modern processes for precipitating colloidal matter in sewage and drinking water, and the use of soap as a detergent, are also briefly reviewed. The author suggests that the hygienic effect of sea-air is due to the presence in it of particles positively charged by the beating of the waves on the shore, which particles precipitate negatively charged bacterial and other colloids; and in regard to the invasion of the body by micro-organisms, he considers that disturbance of the normal colloidal condition of the body-cells or fluids by undesirable electrolytes, salts, or colloids of the "opposite" sign is an ætiological factor.

The author has devoted considerable space to accounts of the preparation of colloidal sols and of their use in therapeutics. In the latter respect he has digested the bulk of the recent and rele-

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